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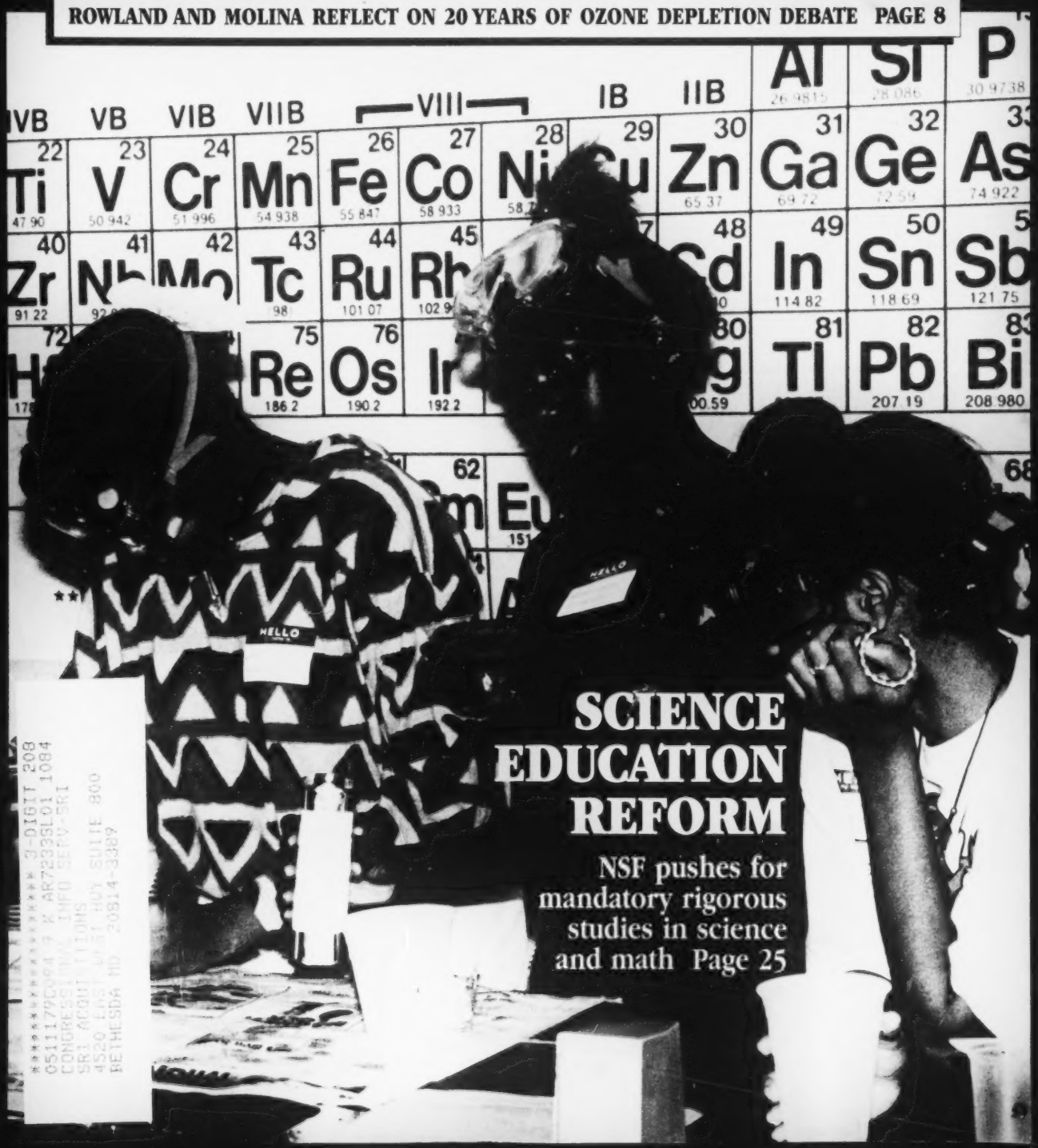
CHEMICAL & ENGINEERING NEWS

C&EN

AUGUST 15, 1994

ROWLAND AND MOLINA REFLECT ON 20 YEARS OF OZONE DEPLETION DEBATE PAGE 8



SCIENCE EDUCATION REFORM

NSF pushes for mandatory rigorous studies in science and math Page 25

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CHEMICAL & ENGINEERING NEWS

C&EN

AUGUST 15, 1994

NEWS OF THE WEEK

■ Explosion and fire break out at Exxon's largest U.S. petrochemical plant, causing minor injuries and likely disrupting the already tight ethylene market. **Page 4**

■ Caltech chemists develop heterogeneous asymmetric catalyst system that allows production of the anti-inflammatory agent naproxen in 96% enantiomeric excess. **Page 5**

■ Clinton Administration is expected to revive the Council on Environmental Quality instead of splitting its functions between EPA and the White House Office of Environmental Policy. **Page 5**

■ Terra Industries proposes a $400 million acquisition of Agricultural Minerals & Chemicals Inc. **Page 6**

■ Rhône-Poulenc reports disappointing first half but expects increase in net income for 1994 as a result of internal restructuring and improvements in company operations. **Page 6**

■ Threat of corrosion of spent nuclear fuel rods stored underwater, leading to possible explosions and release of radioactivity, adds pressure to current U.S.-North Korea talks aimed at halting North Korea's suspected nuclear arms program. **Page 7**

COVER: Chemistry workshop for teenage girls at Institute for Science Education & Science Communication, Columbia College, Chicago. Photo by C&EN's Ernest L. Carpenter

Volume 72, Number 33
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VIEWPOINT

F. Sherwood Rowland and Mario J. Molina, chemists who led the way in ozone depletion research, reflect on the enormous changes that have taken place over the past two decades in the use of chlorofluorocarbons. **Page 8**

BUSINESS

Major U.S. chemical producers post earnings increase for the fifth straight quarter; drug firms and diversified manufacturers also see a rise in earnings. **Page 18**

GOVERNMENT

U.S. signs controversial Law of the Sea treaty after provisions concerning deep-seabed mining are revised to be more compatible with free-market principles. **Page 32**

SCIENCE/TECHNOLOGY

Factors that underlie linear and nonlinear optical phenomena have been linked together in a simple derivative relationship by a team of U.S. and Belgian scientists. **Page 34**

Dante II performs first robotic observations inside the crater of an active volcano, but a malfunction and foul weather leave the robot stranded near the top of Mount Spurr in Alaska. **Page 36**

New alternative fuels user facility and ethanol plant designed to allow scaleup of biofuel technologies is dedicated at the National Renewable Energy Laboratory in Golden, Colo. **Page 37**

ACS NEWS

September local section meetings feature ACS tour speakers and a selection of topics. **Page 39**

COVER STORY

National Science Foundation aims for nationwide comprehensive reform of science and math education through systemic initiatives backed by millions of dollars. Page 25

LETTERS 2
EDITOR'S PAGE 3
CONCENTRATES
Business 15
Government 24
Science/Technology 33
THE DEPARTMENTS
People 41
Newscripts 56

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LETTERS

Fiberglass as a carcinogen

The News of the Week item on the listing of fiberglass as a possible carcinogen by the National Toxicology Program (C&EN, July 11, page 6) incorrectly states that no federal regulations come into play because of the NTP listing. The Occupational Safety & Health Administration's (OSHA) Hazard Communication Standard (29CFR1910.1200) requires that material safety data sheets (MSDS) and labels show that any substance listed as a carcinogen by the International Agency for Research on Cancer (IARC) or in NTP's annual report on carcinogens, or by OSHA, must be designated as a carcinogen. If there is as much as 0.1% of the listed material present in a mixture, then the mixture must be designated as a carcinogen on the MSDS and label. Several states also use IARC and/or NTP as trigger mechanisms in their right-to-know regulations.

It may be true, as Department of Health & Human Services Secretary Donna E. Shalala writes, that "the listing of a substance in the annual report does not establish that any substance presents a risk to persons in their daily lives." The same may be said of an IARC listing; however, the facts don't seem to interfere with the authors of regulations. Mere listing is sufficient to trigger federal and state regulations.

The next time you dig a hole, plant a vegetable, play golf, or go to the beach, consider that IARC has listed crystalline silica (sand) as a carcinogen, and NTP has listed respirable crystalline silica (sand) as a carcinogen—and look out for the coming "risk assessments."

Donald H. Weinblatt
Highland Park, Ill.

Volatile compound removal

The article by Joseph Haggin titled "Catalytic Oxidation Process Cleans Volatile Organics From Exhaust" (C&EN, June 27, page 42) describes three thermal techniques: regenerative, recuperative, and catalytic. There is a fourth technique for removing volatile organic compounds (VOCs) that is also catalytic, at least in part, through enzyme activity in assimilation and dissimilation.

Biofiltration, which is widely practiced in Europe, is now "catching on" in the U.S. in several versions for control of VOCs and odor. The several types of biofilters include biomass beds of mixtures of compost, inert bulking media, nutrients, neutralizing agents, and sometimes activated carbon; open topsoil beds; and biofilm on packed beds supplied with nutrients.

These techniques are especially useful for emissions at ambient temperature and concentrations up to 1,000 or 1,500 ppm by volume. They are most economical in capital, operating, and maintenance costs and they will be increasingly relied on for control of many VOCs.

A. B. Mindler
International Hydronics Corp.
Rocky Hill, N.J.

'Innovative' EPA?

The July 25 issue of C&EN (page 9) announces the Environmental Protection Agency's plan to change its emphasis from individual chemicals to industries. How creative! Except that when EPA was formed in 1971, that was the approach in EPA's Office of Research & Development, where I worked. The only difference was that we didn't need an assistant administrator for each industry. Individuals or branches simply were devoted to one or more industries, learned the manufacturing and environmental technology, developed a rapport with the firms and associations, and worked together to identify and solve the industry's environmental problems.

Promising research ideas that needed development were funded by cooperative grants from the industry associations and the EPA Office of R&D—and were often approved in weeks or even days.

Pollution prevention? It hadn't been invented yet, but that didn't keep us from devising solutions that recovered chemicals, reused water and other solvents, reclaimed heat or energy, or whatever seemed to be cost-effective. Did we solve all the problems? Did we get total cooperation? Were all our projects successful? Obviously not, but great progress was made during the decade toward eliminating significant environmental problems.

As with EPA Administrator Carol Browner's "innovative" new approach, I shake my head at many of today's "innovative" technologies—carbon adsorption, reverse osmosis, UV/ozone, sulfide precipitation of metals, and so on—all of which were already in use or developed during the seventies. Many of the same technologies are still being marketed today—with minor changes—as "research," often by the same firms.

Herb Skovronek
Morris Plains, N.J.

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Chemical Companies' Earnings Improve For Fifth Consecutive Quarter

William J. Storck,
C&EN Northeast News Bureau

Chemical companies posted more earnings increases in this year's second quarter. Results released last month show that chemical companies' earnings grew for the fifth straight three-month period and were up at double-digit rates for the third consecutive quarter.

Results also improved for pharmaceutical firms and diversified companies that produce significant amounts of chemical products. As a group, only oil companies that produce chemicals had lower earnings in the second quarter than they did in the same period a year earlier; however, the decline for most of these companies came in their oil operations, with improvement in chemicals.

For 30 major chemical companies regularly surveyed by C&EN, earnings from continuing operations, excluding significant nonrecurring and extraordinary items, rose an average of 28% over last year's second quarter to a combined $1.59 billion. Combined sales increased about 5% to $21.3 billion. The result was an increase in the aggregate profit margin for the group to 7.5% from 6.1% in the same period a year earlier.

For the first half of this year, earnings for the same 30 companies rose 24% to about $2.84 billion, and sales increased 5% to $41.1 billion. The average profit margin for the group was 6.9%, up from 5.8% in the first half of 1993.

For other producers of chemicals, earnings for 10 pharmaceutical companies increased 29% for the quarter to $3.29 billion on a 12% sales increase to $20.5 billion. That provided a profit margin of 16.0%, up from 13.9% in second-quarter 1993. For the half, earnings

Chemical industry leaders for the second quarter . . .

Sales

Rank 1994		$ Millions	Rank 1993
1	Dow Chemical	$4,934.0	1
2	Monsanto	2,269.0	2
3	W. R. Grace	1,236.9	4
4	Union Carbide	1,177.0	3
5	Eastman Chemical	1,047.0	5
6	Rohm and Haas	944.0	6
7	Air Products	868.4	7
8	Arco Chemical	824.0	8
9	Morton International	730.8	12
10	Olin	708.1	10

Earnings[a]

	$ Millions	Rank 1993
Monsanto	$258.0	2
Dow Chemical	251.0	1
Rohm and Haas	95.0	6
Eastman Chemical	83.0	3
Union Carbide	73.0	11
Arco Chemical	68.0	10
Great Lakes Chemical	67.7	5
Air Products	65.8	4
W. R. Grace	65.7	9
International Flavors	64.9	7

Profitability

	Earnings as % of sales	Rank 1993
International Flavors	18.8%	1
Great Lakes Chemical	12.9	2
Monsanto	11.4	8
Loctite	11.4	3
Ethyl	11.0	7
Betz Laboratories	10.5	3
Crompton & Knowles	10.4	6
Lubrizol	10.1	10
Rohm and Haas	10.1	13
Georgia Gulf	9.6	17

. . . and for the first half of 1994

Sales

Rank 1994		$ Millions	Rank 1993
1	Dow Chemical	$9,475.0	1
2	Monsanto	4,270.0	2
3	W. R. Grace	2,313.7	4
4	Union Carbide	2,303.0	3
5	Eastman Chemical	2,030.0	5
6	Rohm and Haas	1,800.0	6
7	Air Products	1,727.0	7
8	Arco Chemical	1,581.0	8
9	Morton International	1,539.1	10
10	Hercules	1,386.0	9

Earnings[a]

	$ Millions	Rank 1993
Monsanto	$452.0	1
Dow Chemical	424.0	2
Rohm and Haas	162.0	6
Eastman Chemical	139.0	5
Air Products	138.9	3
Union Carbide	136.0	12
Great Lakes Chemical	134.6	4
Morton International	129.9	11
International Flavors	123.9	7
Hercules	117.0	9

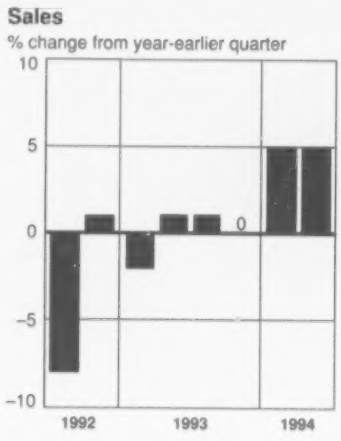
Profitability

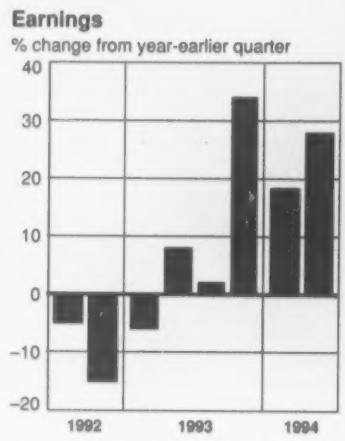
	Earnings as % of sales	Rank 1993
International Flavors	18.5%	1
Great Lakes Chemical	13.8	2
Loctite	11.4	3
Betz Laboratories	10.6	4
Monsanto	10.6	10
Crompton & Knowles	10.0	6
Nalco Chemical	9.7	5
Lubrizol	9.5	8
Rohm and Haas	9.0	11
Ethyl	8.7	7

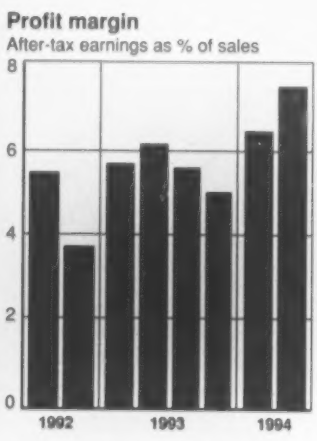
Note: Based on 30 chemical companies listed on page 20. a After taxes.

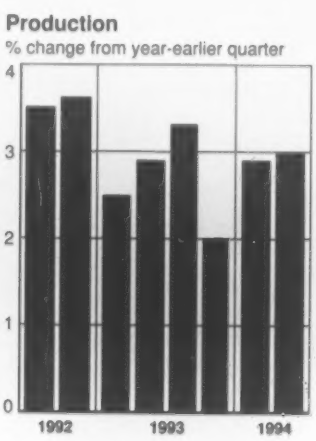
Chemical industry 1994 second-quarter results

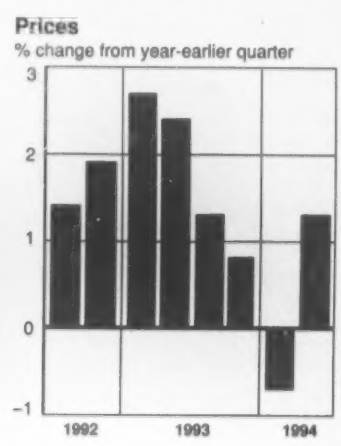
- **Sales increased 5%**
- **Earnings were up 28%**
- **Profit margins hit 7.5%**
- **Production rose 3.0%**
- **Prices increased 1.3%**











Note: All sales, earnings, and profit-margin data are based on 30 chemical companies listed on page 20.

were up 15% to $6.74 billion on an 11% sales increase to $40.6 billion. Profitability for the half improved to 16.6% from 16.0% a year earlier.

For 10 diversified companies, earnings soared 32% in the quarter to $1.70 billion, on a 7% sales increase to $22.1 billion. Profit margin for the firms hit 7.7%, compared with 6.2% a year earlier. For the first half, earnings increased 27% to $3.05 billion on a 5% sales increase to $42.3 billion. As a result, the profit margin rose to 7.2% from 6.0% in first-half 1993.

The 11 oil companies surveyed by C&EN suffered, however, with earnings declining 29% in the second quarter to $2.48 billion on a 2% decrease in sales to $78.5 billion. This caused the aggregate profit margin for the group to fall to 3.2% from $4.3% a year earlier. For the first half, earnings dropped 17% to $5.43 billion while sales declined 3% to $151 billion. Profitability fell to 3.6% from 4.2% a year earlier.

Most of the damage to oil companies' earnings in the second quarter, however, came from the oil side of the business. Chemical results actually improved at many of the firms. For instance, Mobil's chemical earnings of $39 million were three times their value in second-quarter 1993. Shell Oil's chemical earnings, excluding nonrecurring items, improved 169% to $94 million, and Exxon's earnings from chemical operations were up 121% to $190 million for the second quarter.

The chemical industry in the second quarter this year continued to benefit from the improving U.S. economy and also started to get some help from slowly rebounding economies elsewhere in the world.

Major end-use markets continued to improve for chemicals as finances in the automobile and housing sectors of the economy improved once again. And even agriculture, which has been slow off the mark in the economic recovery, showed some improvement in

Major chemical companies increased earnings 28% on 5% sales increase in second quarter

	SECOND-QUARTER 1994						FIRST-HALF 1994			
	Sales	Earnings[a]	Change from 1993		Profit margin[b]		Sales	Earnings[a]	Change from 1993	
	($ millions)		Sales	Earnings	1994	1993	($ millions)		Sales	Earnings
Air Products	$ 868.4	$ 65.8	5%	–7%	7.6%	8.6%	$ 1,727.0	$ 138.9	4%	–5%
Albemarle	269.9	15.3	19	278	5.7	1.8	511.7	25.4	16	171
Arco Chemical	824.0	68.0	3	45	8.3	5.9	1,581.0	113.0	1	14
Betz Laboratories	179.7	18.9	5	1	10.5	11.0	352.6	37.4	4	–2
Cabot	428.8	22.0	2	20	5.1	4.4	863.7	44.3	5	37
Crompton & Knowles	154.5	16.1	5	3	10.4	10.6	288.0	28.9	2	3
Dow Chemical	4,934.0	251.0	2	22	5.1	4.3	9,475.0	424.0	3	27
Eastman Chemical	1,047.0	83.0	3	11	7.9	7.4	2,030.0	139.0	4	4
Ethyl	276.1	30.4	3	13	11.0	10.0	510.1	44.4	–2	–7
First Mississippi	149.4	8.9	25	440	6.0	1.4	279.0	13.8	25	768
H. B. Fuller	272.4	9.3	10	6	3.4	3.5	514.9	13.3	8	14
Geon	284.5	12.8	16	392	4.5	1.1	545.8	19.8	16	nm
Georgia Gulf	208.2	20.0	7	74	9.6	5.9	401.1	32.7	6	51
W. R. Grace	1,236.9	65.7	13	22	5.3	4.9	2,313.7	103.9	11	21
Great Lakes Chemical	525.9	57.7	14	–3	12.9	15.2	974.6	134.6	9	0
Hercules	706.0	64.6	–1	18	9.2	7.7	1,386.0	117.0	0	19
IMC Fertilizer	435.6	15.2	–3	nm	3.5	def	846.1	20.6	89	nm
International Flavors	345.2	64.9	7	7	18.8	19.0	668.7	123.9	6	6
Loctite	177.8	20.2	12	16	11.4	11.0	337.7	38.5	10	4
Lubrizol	408.5	41.4	4	32	10.1	7.9	809.0	77.2	7	16
Monsanto	2,269.0	258.0	2	29	11.4	9.0	4,270.0	452.0	2	33
Morton International	730.8	58.6	26	60	8.0	6.3	1,539.1	129.9	25	53
Nalco Chemical	352.0	33.1	1	–13	9.4	11.0	688.2	66.9	0	–9
Olin	708.1	27.6	13	93	3.9	2.3	1,313.0	42.9	8	65
Petrolite	90.6	4.3	5	–17	4.8	6.0	182.4	9.7	10	–3
Praxair	645.0	47.0	4	24	7.3	6.1	1,256.0	89.0	3	25
Rohm and Haas	944.0	95.0	7	51	10.1	7.1	1,800.0	162.0	5	34
Stepan	112.3	4.1	2	21	3.6	3.0	219.6	6.1	–2	–24
Union Carbide	1,177.0	73.0	–5	78	6.2	3.3	2,303.0	136.0	–5	64
Witco	565.6	29.2	3	40	5.2	3.8	1,119.0	51.3	1	29
TOTAL	**$21,327.1**	**$1,591.3**	**5%**	**28%**	**7.5%**	**6.1%**	**$41,106.0**	**$2,836.4**	**5%**	**24%**

a After-tax earnings from continuing operations, excluding significant extraordinary and nonrecurring items. b Earnings as a percentage of sales. **nm** = not meaningful. **na** = not available.

the quarter—leading to better results for fertilizer manufacturers.

The result was that production of chemicals and products increased 3.0% for the quarter, and prices, after moving down slightly in the first quarter, rose 1.3% in the second quarter on a year-to-year basis. More telling were government data for large-volume industrial chemicals. Federal Reserve Board data show production of industrial chemicals and synthetic materials increasing 5% in the second quarter. However, according to the Department of Labor, while prices of industrial chemicals continued to decline in the quarter—0.6% from the year-earlier three-month period—in June, they finally moved up 0.8% from 12 months earlier.

In particular, two big polymer markets improved in the quarter. Production of plastics in May, the latest month for which data are available from the Society of the Plastics Industry, was up almost 14% from the year-earlier month, while sales and captive use increased almost 11%. Fibers also showed a healthy increase with shipments up almost 6% in the quarter, according to Fiber Economics Bureau data. In support of these data, Dow Chemical noted that its operating income from plastics increased 117% in the quarter on strong global volume and price increases for polyolefins in North America and polystyrene in Europe.

Government data also show that demand for chemicals increased substantially in the second quarter. According to Commerce Department figures, the value of shipments of chemicals and allied products rose about 7.5% in the second quarter, while shipments value of the industrial chemicals subcategory increased an even greater 8.6%.

Producers continued to cut costs to raise their profit margins during the second quarter. For instance, downsizings of staff continued, according to the Labor Department. In the second quarter, some 23,000 fewer employees worked in the chemicals and allied products industry than did so a year earlier.

Monsanto's chairman and chief executive officer, Richard J. Mahoney, indicates that most of these conditions

FIRST-HALF 1994		12-MONTH RUNNING DATA			
Profit margin[b]		Change from 1993		Profit margin[b]	
1994	1993	Sales	Earnings	1994	1993
8.0%	8.8%	3%	–2%	8.0%	8.4%
5.0	2.1	na	na	na	na
7.1	6.3	2	7	7.4	7.0
10.6	11.2	0	–12	10.1	11.4
5.1	3.9	3	46	4.5	3.2
10.0	9.9	3	9	9.4	8.8
4.5	3.6	–1	25	3.8	3.0
6.8	6.9	2	–13	6.6	7.8
8.7	9.2	na	na	na	na
4.9	0.7	15	387	3.5	0.8
2.6	2.5	6	–11	2.9	3.4
3.6	def	15	nm	2.6	def
8.1	5.7	2	31	6.9	5.4
4.5	4.1	–6	16	5.4	4.4
13.8	15.1	14	7	14.5	15.4
8.4	7.1	0	29	8.3	6.4
2.4	def	61	nm	def	0.7
18.5	18.6	4	4	17.0	17.1
11.4	12.1	5	–11	10.8	12.7
9.5	8.8	6	29	8.4	7.0
10.6	8.2	3	49	7.4	5.2
8.4	6.9	23	42	7.9	6.9
9.7	10.7	0	–2	10.5	10.7
3.3	2.1	7	51	2.3	1.6
5.3	6.0	13	17	5.5	5.4
7.1	5.8	–1	25	6.7	5.3
9.0	7.1	3	5	6.5	6.3
2.8	3.6	–1	–28	2.5	3.4
5.9	3.4	–7	79	5.0	2.6
4.6	3.6	6	44	4.7	3.5
6.9%	5.8%	1%	14%	5.6%	5.2%

def = deficit.

prevailed at his company: "Second-quarter and first-half results were driven by continuing worldwide volume gains for our agricultural products, strengthening economic conditions in North America and Europe ... and across-the-board cost control and productivity measures. We are well on our way to achieving our financial goals," he says.

Along with volume increases, pricing, which seems finally to be turning up, came in for some attention from chemical company executives in the quarter. At Dow Chemical, for example, Enrique C. Falla, the company's executive vice president, says: "Supply is tightening for chlor-alkali products, ethylene, and styrene, resulting in future higher prices for many of our basic and specialty chemicals and plastics. We anticipate that ongoing price increases, leveraged by productivity improvements, will help us maintain our present momentum and lead to further earnings growth through 1994." Falla notes that caustic soda prices were weak compared with a year ago but that they are now rising with significant improvements expected in 1995.

Robert D. Kennedy, Union Carbide's chairman and chief executive officer, says, "Earnings improvement resulted mainly from higher volumes from many of our key products and from higher prices for high and linear low-density polyethylene." However, he notes that prices and margins may come under pressure by year's end as additional ethylene and derivatives capacity comes on-line.

At Geon Co., the large polyvinyl chloride producer spun off from BF Goodrich, chairman and chief executive officer William F. Patient says: "Our aggressive productivity programs are allowing us to capitalize on stronger consumer demand while we drive our costs to lower levels. The strong demand also allowed us to increase prices during the quarter."

However, some companies are still complaining about product pricing. Eastman Chemical notes that physical volume increases in some product areas of its industrial chemical segment were higher than sales increases because of lower prices in the quarter.

DuPont notes lower selling prices in its fibers and polymers sectors as earnings in its chemicals operations declined for the quarter. DuPont, in the second quarter, was the rare company whose oil operations improved while chemicals faltered.

Many of the companies note better results as foreign economies began to emerge from recession. At specialty chemical maker Betz Laboratories, president and chief executive officer William R. Cook says, "Our second-quarter results reflect improving business conditions within the industrial sector of the economy. Our foreign operations had a particularly strong quarter and posted double-digit sales volumes in Canada, the Caribbean, Australia, and throughout most of Europe."

All of PPG Industries' businesses—coatings, glass, and chemicals—recorded volume gains as a result of continued economic expansion in North America and strengthening European markets. Company chairman and chief executive officer Jerry E. Dempsey says, "We believe Europe is now in a sustained recovery, commodity chemical prices have stopped their decline, and we remain optimistic about our business in North America and the Asia-Pacific region."

On the other hand, surfactant manufacturer Stepan's chairman and president, F. Quinn Stepan, says, "The company's Mexican and Canadian opera-

Ground rules for C&EN earnings analysis

C&EN's quarterly report on financial performance of the U.S. chemical industry contains data from the 30 largest U.S. basic chemical companies and from 21 oil and diversified companies, each with more than $200 million in annual chemical sales, plus 10 pharmaceutical companies.

To be included in the table of basic chemical producers, a company must have at least 50% of its sales in chemicals. That is why DuPont, for example, is included in the table of diversified manufacturers.

In referring to chemical sales, C&EN means those chemicals whose molecular composition has been changed in the course of manufacture. Hence, chemical sales include those of traditional categories of basic petrochemicals and inorganics, organic intermediates and inorganic compounds, polymers such as plastics and fibers, and agricultural chemicals and specialty derivatives.

Earnings fell 29% for oil companies but rose 32% for diversified firms and 29% for drug firms

	SECOND-QUARTER 1994						FIRST-HALF 1994					
	Sales	Earnings[a]	Change from 1993		Profit margin[b]		Sales	Earnings[a]	Change from 1993		Profit margin[b]	
	($ millions)		Sales	Earnings	1994	1993	($ millions)		Sales	Earnings	1994	1993
OIL AND GAS COMPANIES												
Amoco	$ 8,035.0	$ 396.0	11%	–19%	4.9%	6.7%	$ 14,800.0	$ 794.0	4%	–10%	5.4%	6.3%
Ashland	2,703.0	44.0	4	–12	1.6	1.9	4,910.0	76.9	–2	17	1.6	1.3
Chevron	8,800.0	262.0	–11	–54	3.0	5.7	17,100.0	686.0	–10	–36	4.0	5.7
Exxon	27,319.0	885.0	–2	–28	3.2	4.4	53,283.0	2,045.0	–3	–15	3.8	4.4
Fina	838.1	13.4	–10	–78	1.6	6.7	1,615.5	38.4	–10	–38	2.4	3.5
Mobil	16,237.0	513.0	0	–1	3.2	3.2	31,292.0	1,048.0	0	4	3.3	3.2
Occidental Petroleum	2,162.0	–19.0	8	nm	def	3.7	4,268.0	–59.0	2	nm	def	3.8
Phillips Petroleum	2,995.0	60.0	–7	–56	2.0	4.2	5,879.0	169.0	–6	–13	2.9	3.1
Shell Oil	5,126.0	257.0	–6	20	5.0	3.9	9,940.0	475.0	–6	18	4.8	3.8
Sun Co.	2,253.0	–1.0	–8	nm	def	1.7	4,320.0	33.0	–9	–57	0.8	1.6
Unocal	2,045.0	65.0	–3	–26	3.2	4.2	3,961.0	127.0	–10	–32	3.2	4.2
TOTAL	**$78,513.1**	**$2,475.4**	**–2%**	**–29%**	**3.2%**	**4.3%**	**$151,368.5**	**$5,433.3**	**–3%**	**–17%**	**3.6%**	**4.2%**
DIVERSIFIED MANUFACTURERS												
AlliedSignal	$ 3,187.0	$ 196.0	4%	17%	6.1%	5.5%	$ 6,173.0	$ 365.0	4%	17%	5.9%	5.3%
DuPont	10,161.0	839.0	6	56	8.3	5.6	19,351.0	1,481.0	4	48	7.7	5.4
Engelhard	633.4	31.9	12	12	5.0	5.1	1,191.1	54.6	13	23	4.6	4.2
Ferro Corp.	300.2	12.0	7	–12	4.0	4.9	583.5	23.3	9	–13	4.0	5.0
FMC	1,053.8	67.3	8	8	6.4	6.4	1,962.1	113.4	4	5	5.8	5.7
Freeport-McMoRan	468.4	13.9	11	395	3.0	0.7	918.0	37.3	27	nm	4.1	def
BF Goodrich	540.5	18.5	19	208	3.4	1.3	1,042.9	23.4	26	nm	2.2	def
3M	3,772.0	343.0	7	4	9.1	9.4	7,404.0	649.0	5	–2	8.8	9.4
PPG Industries	1,619.3	148.1	6	39	9.1	7.0	3,096.2	270.0	4	16	8.7	7.9
Vulcan Materials	326.7	33.7	7	7	10.3	10.3	543.6	28.5	5	–8	5.2	6.0
TOTAL	**$22,062.3**	**$1,703.3**	**7%**	**32%**	**7.7%**	**6.2%**	**$42,265.4**	**$3,045.5**	**5%**	**27%**	**7.2%**	**6.0%**
PHARMACEUTICAL COMPANIES												
Abbott Laboratories	$ 2,204.0	$ 376.6	6%	9%	17.1%	16.7%	$ 4,419.3	$ 742.8	7%	7%	16.8%	16.8%
American Home Products	1,977.9	300.0	4	4	15.2	15.1	4,121.9	715.8	3	4	17.4	17.1
Baxter International	2,316.0	144.0	5	9	6.2	6.0	4,509.0	275.0	6	46	6.1	4.4
Bristol-Myers Squibb	2,970.3	542.0	6	4	18.2	18.6	5,804.2	1,123.0	4	3	19.3	19.7
Eli Lilly	1,678.5	346.6	8	0	20.6	22.2	3,315.5	677.3	6	–6	20.4	23.1
Merck	3,792.0	764.1	47	343	20.2	6.7	7,306.3	1,439.2	48	83	19.7	15.9
Pfizer	1,923.3	257.2	10	23	13.4	12.0	3,906.2	627.9	8	8	16.1	16.1
Schering-Plough	1,190.1	240.7	6	13	20.2	19.0	2,351.7	493.9	6	13	21.0	19.7
Upjohn	891.0	120.1	0	–4	13.5	14.0	1,796.8	254.8	–1	–8	14.2	15.3
Warner Lambert	1,552.2	196.8	7	4	12.7	13.1	3,025.1	387.1	9	4	12.8	13.3
TOTAL	$20,495.3	$3,288.0	12%	29%	16.0%	13.9%	$40,556.0	$6,736.8	11%	15%	16.6%	16.0%

a After-tax earnings from continuing operations, excluding significant extraordinary and nonrecurring items. b After-tax earnings as a percentage of sales. **nm** = not meaningful. **na** = not available. **def**=deficit.

tions and the broad commercial base in the U.S. all showed improvement, while earnings from the European operations continued to reflect competitive pressures."

The results seen in the second quarter and through the first half continue to lend an air of cautious optimism for at least the remainder of 1994 to the chemical industry. At Rohm and Haas, J. Lawrence Wilson, chairman and chief executive officer, strikes the tone for the industry, saying: "Earnings are up—that's good news, but they still are below the levels we feel we need to do well in an industry where competition is becoming more and more fierce. It remains critically important for us to maintain good control of internal costs to become more efficient in meeting customer needs and more productive overall." Wilson does say, however, that the company's 1994 results will be substantially above 1993 earnings and may exceed the company's record performance of $230 million in 1988, "but currency changes and the current upward trend in raw material costs could influence that comparison." □

NSF Stakes Millions On Sweeping Reform Of Science, Math Education

■ ***State, urban, and rural systemic initiatives aim to transform entrenched practices and attitudes; critics wary of approach***

Pamela S. Zurer, C&EN Washington

Last May, the National Science Foundation announced the first major awards under its year-old Urban Systemic Initiative (USI). Nine cities, each with large numbers of children living in poverty, will receive $15 million over five years to improve science, mathematics, and technology education. The agency's total commitment could grow to as much as $375 million if the 16 other cities eligible for USI awards eventually win them.

Although big bucks for NSF, the USI awards are relatively small change for the cities, some of which juggle billion-dollar education budgets. Yet NSF expects the USI money to catalyze sweeping changes that ultimately will close the gap in achievement between the impoverished urban school districts' mostly minority students and their white suburban counterparts.

NSF wants the cities to root out the entrenched attitudes and practices that relegate the majority of their students to boring, "dumbed-down" classes where little is expected of them. Instead, the agency envisions educational systems where all children—whether headed for the work force or college—are required to take challenging yet engaging math and science courses every year.

"This program is designed to break rank with the situation in which mathematics and science education has been characterized by low student achievement, minimally demanding courses, and a variety of other less than exemplary developments," said Luther S. Williams, NSF assistant director for education and human resources, when the awards were announced.

"The end result has been graduates who are rarely well prepared for higher education in science, mathematics, or engineering and, more importantly, are ill-prepared for employment of an increasingly technological nature," he continued. "We expect to revise all elements of the status quo."

NSF's strategy for transforming the status quo is through what it calls systemic reform—a comprehensive approach that tackles all components of the educational system at once. The urban initiative, with its special emphasis on improving performance of minority students, is only one element in the ambitious reform effort of NSF's Directorate for Education & Human Resources (EHR). In addition, half of the states are each receiving up to $10 million over five years in the ongoing Statewide Systemic Initiative (SSI). And just getting under way is the Rural Systemic Initiative, directed at improving science education in rural counties with high poverty rates.

Systemic reform means that NSF no longer wants to support isolated, piecemeal projects whose benefits never spread beyond the school or classroom where they were developed. Instead, the agency is trying to get educational establishments to simultaneously implement improved curricula, teacher enhancement programs, innovative testing methods, and policies that support the changes. It is encouraging cooperation among school systems, parents, local business communities, uni-

Systemic initiative awards span much of the country

a Experimental Program To Stimulate Competitive Research. **Source:** National Science Foundation

versities, and museums. And NSF insists that its partner cities and states set clear goals and demonstrate how they are achieving them.

The education directorate budget of NSF has more than doubled in the 1990s, growing much faster than those of the agency's research directorates. Within EHR, the Office of Systemic Reform has been expanding most rapidly. It commands $110 million this fiscal year, almost 20% of EHR's $570 million budget and as much as the entire directorate received in 1987.

Furthermore, Williams has directed that programs in EHR's other divisions must reinforce systemic reform. For example, programs to help teachers improve their scientific knowledge base now also are designed to get them thinking about how they teach and the different ways students learn. "We no longer let a thousand flowers grow," says Margaret B. Cozzens, director of the elementary, secondary, and informal education division. "We look at the big picture."

For the most part, the cities and states that are the targets of NSF's systemic reform effort welcome both the infusion of funds and the imprimatur of the prestigious agency for their efforts to improve science and math education. But many academic researchers, science educators, and professional society officials, who constitute the NSF education directorate's more traditional clientele, are uneasy about the new thrust.

In the past, the education directorate has funded scientists and science educators to develop courses or work directly with teachers. Now, the systemic initiative awards are going to state and local entities that do not have the same direct connection to science. The political context worries many onlookers.

Only a few of these critics are willing to speak for the record, because almost anyone deeply involved in science education is either funded by NSF or hopes to be. But all express the same fear: The agency is pouring millions of dollars into the same state and local bureaucracies that have neglected the very problems they are now supposedly correcting. Will NSF's funds effect any real change? How can it demonstrate whether the systemic initiatives are working? Will the agency be called on the carpet in a few years, unable to prove that its systemic reform programs have stimulated any improvement?

Much of what NSF hopes to accomplish with systemic reform involves changes in policies and attitudes—intangibles that are difficult to measure. Even if some school systems do reform themselves, critics worry that it will be impossible to show that it was NSF's influence that tipped the balance.

Congress has specifically directed EHR to evaluate the effectiveness of its programs. The division of research, evaluation, and dissemination, created in 1992, oversees independent reviews of EHR's programs, evaluating about a third at any one time, according to division director Daryl E. Chubin. Judging the effectiveness of systemic reform is requiring the invention of new kinds of evaluation tools, because systemic reform aims to change not just the educational system but its surrounding environment as well.

So far, Congress has been generally supportive of the systemic reform movement, acknowledging it's still too early to judge whether the systemic initiatives have been a success. The effort even has a cheerleader in Sen. Barbara L. Mikulski (D.-Md.), chairman of the appropriations subcommittee that controls NSF's budget, who speaks passionately of her hopes for USI. And outside government, the systemic effort has other champions who believe the risk is worth the potential rewards.

"Anybody with any sense ought to have the same fears. These initiatives are high risk, but they are potentially high payoff," says Shirley Malcolm, head of the American Association for the Advancement of Science's education and human resources effort, which has its own, much smaller scale systemic reform program. Malcolm, a member of NSF's policy-setting body, the National Science Board, as well as of the President's Committee of Advisers on Science & Technology, is a staunch defender of NSF's systemic reform movement.

C&EN staff photos

Danek (left): kids deserve a lot more; Williams (above): revise the status quo

"With systemic reform, for the first time we are really trying to address all the critical issues," Malcolm tells C&EN. "People have been saying: 'We need better curricula. The teachers need training. We need good materials.' Yes, yes, and yes! But those are only part of the puzzle. We need to change policy. We need to change the system that doesn't believe all kids can succeed.

"We've got to try," she continues. "Just because we don't know how to do something is no reason not to try to do it. We learn in the process. The risk of doing nothing is much greater than the risk of undertaking some kind of systemic initiative."

Doing nothing, Malcolm says, would perpetuate a system that does not serve all children well in math, science, and technology. Across the country, there is an enormous disparity between minority and white students. NSF reports that three quarters of white eighth graders in the U.S., but only 37% of Hispanic and 26% of black students, perform at or above basic achievement levels in math.

"In my view, the performance gap is the most critical problem in science and mathematics today," says Joseph D. Danek, head of EHR's Office of Systemic Reform. A Ph.D. science educator, Danek has helped create a number of cutting-edge programs in his two decades at NSF. "We can't have millions of students in certain school districts in this country coming out of 12 years of education at a fourth-grade reading level and a third-grade mathematics capability. That's totally irresponsible.

"Those kids deserve a hell of a lot more. They deserve the ability to be able to find a job at some place other than McDonald's, where they don't even have to calculate change. We can't grow the country, can't innovate like that. It's crazy."

Danek points out that, during the 1980s, NSF's education focus was on the development of Ph.D.s for careers in science and engineering. "People worried about dropouts from the education 'pipeline,' about how to get students to Ph.D.s," he says. For the 95% of students who don't pursue math, science, or engineering as a career, the goal was an appreciation of those seemingly formidable subjects.

But in the past several years, EHR has embraced an important conceptual change that underlies the systemic reform effort. Now the education directorate aims to ensure that all students, not just the best and brightest, are prepared for useful lives in today's technology-oriented world through rigorous study of science and math.

"I don't subscribe to the notion that the role of NSF should be to make provisions for merely acquainting students with science," Williams tells C&EN. "We must move ... to science and mathematics being as indispensable to what it means to be an educated person as is English.

Malcolm: high risk, high payoff

"American students basically have a K–9 [kindergarten through ninth grade] system in mathematics and science education, except for those few rare individuals who are very interested," he notes. "After the ninth grade, there are no requirements for students to actually seriously study science and mathematics."

Instead, students who are not perceived as destined for college take courses such as applied math or general science, which demand little and cover the same ground over and over. In the worst cases, Williams says, students are funneled into remedial courses meant to teach them what they should have learned earlier. Rather than shunting those children out of a system that fails them, he says, "it would be better to change the system."

NSF's education directorate itself has undergone enormous change since what was then called the Directorate for Science & Engineering Education was virtually abolished by the Reagan Administration in spring 1982. It was reestablished a year and a half later after the 1983 report "A Nation at Risk" concluded that the future of the U.S. was threatened by the weak state of U.S. education in general and science education in particular.

By the end of the 1980s, the directorate was commanding close to 10% of NSF's then roughly $2 billion budget. Under the energetic leadership of Bassam Z. Shakhashiri, now professor of chemistry at the University of Wisconsin, Madison, Congress regularly appropriated more money for the directorate than the President requested.

In 1990, outgoing NSF director Erich Bloch reorganized the directorate and replaced Shakhashiri. NSF's programs on women, minorities, and the handicapped were combined with its existing education programs to create the Directorate for Education & Human Resources. Williams, a former president of historically black Atlanta University who had been serving as a senior science adviser to Bloch, was put in charge. EHR today accounts for almost 20% of NSF's fiscal 1994 budget of $3 billion.

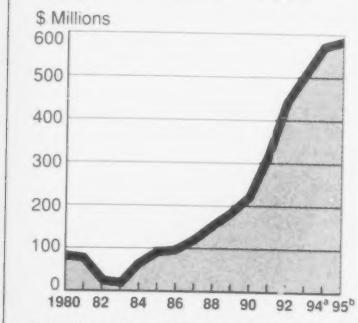
According to Danek, the roots of systemic reform can be traced to an older NSF program that was moved into EHR during a later reorganization: the Experimental Program To Stimulate Competitive Research (EPSCoR). That program was begun in the late 1970s to respond to complaints from Congress that a relatively few prestigious research universities continually corner the bulk of federal research funding. EPSCoR aims to help states develop the capacity to compete with Stanford University, Massachusetts Institute of Technology, and the like.

"NSF started what amounts to the first systemic, comprehensive effort to get into a state and see what the problems and issues are," says Danek, who helped create the program. "We ask the states: 'What's your current status? Where do you want to be?' "

Many of the states that have worked with NSF in EPSCoR are now part of the Statewide Systemic Initiative (SSI). Launched in 1990, SSI requires commitments from governors and the states' top education officials to adopt policies, personnel practices, and textbooks and curricula that will lead to lasting change in their science education programs. The states are supposed to work with industry and local communities and at least match NSF's $2 million a year with funds from other sources.

EHR made the first of its five-year SSI awards to 10 states in 1991 and

Education budget more than doubled in 1990s



Note: Data for fiscal years reflect current composition of Education & Human Resources Directorate. **a** Current plan. **b** Budget request
Source: National Science Foundation

added 10 more states and Puerto Rico in 1992 and another five states in 1993. The awards are not grants but cooperative agreements that can be phased out if the awardees do not perform up to expectations. The state programs are asked to continually evaluate themselves and are monitored regularly by NSF staff and outside experts.

"The whole notion of monitoring progress has to begin the day we make awards," says Williams. "The temptation to start in good faith and not carry through is enormous.

"This is a very different way of doing things than previously. Consider the total amount of money that was spent by colleges and universities, federal agencies, and private foundations on science and engineering and mathematics education over the past 20 years. What's the return? What's the outcome?

"The monies accomplished very little," he says. "But worse, there is no body of evidence to which you can go as a scholar to find explicit explanations as to why it didn't work. The job didn't get done and there's been no effort to explain why."

To change that situation, every proposal that NSF funds under the systemic initiatives sets out goals that get more specific as the five-year award period progresses. The education directorate expects to see change in less tangible areas such as goals, leadership, organization, and community involvement as well as in more concrete aspects like course requirements, teacher training, and student achievement.

"In these systemic reforms you are looking for policy changes that will dictate a whole different set of scenarios," Danek says. "When you say all kids will take science and math for three years, you are saying 'I'm not just going to worry about the best and brightest.' That translates to the fact that you're going to have to figure out how to get teachers to believe that all the kids can [succeed].

"You are trying to get massive change in beliefs and attitudes and behaviors in people. This is quite different from a research grant."

Danek explains the types of systemwide changes NSF hopes to see the cities and states make: "Can they reduce resistance to change? Have they brought together groups of people who can make a difference? Or it is just the same old organizational structure we've had before with the same people doing the same thing?"

This past winter, EHR sponsored a comprehensive "midpoint" review of the 10 states that were in the first group to win SSI awards. The outside review panel of experts identified concerns in six of the 10 states' programs. A few states are in deep trouble, and one—Rhode Island—has had its funding cut off.

Rhode Island was phased out after receiving $5 million of an expected $9.3 million award. "If you looked at what we got for the $5 million, you would question whether it was a good investment," Danek says. He notes the state had changed project directors three times, and then it was doubtful whether its program would have a significant impact on school improvement.

The unprecedented termination of such a major project is helping supporters of EHR blunt criticism that the systemic initiatives are becoming entitlement programs. In an April letter to the appropriations subcommittee chaired by Sen. Mikulski, for example, the American Chemical Society opposed NSF's expansion of its systemic reform programs before their effectiveness has been established.

Critics also worry that decisions about which states or cities get the awards are too vulnerable to political influence. However, although Rhode Island's senior Senator, Democrat Claiborne Pell, chairs an important subcommittee with jurisdiction over NSF's education programs, that state's systemic initiative funding was not saved.

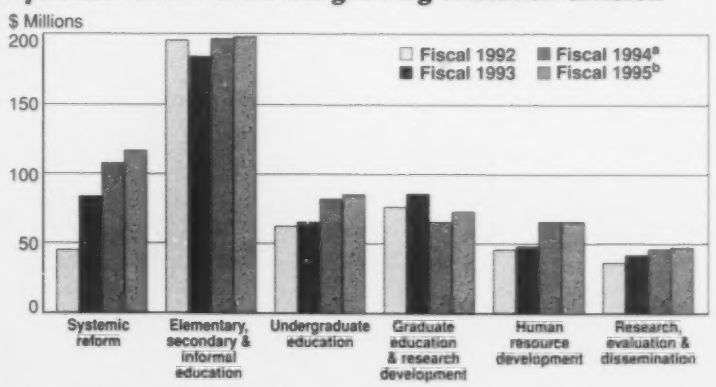
"If a state doesn't stick to the agreed plan, it should be terminated," says a staff member of the House Committee on Science, Space & Technology. "It's a healthy sign NSF cut off Rhode Island. There's a danger that when you start something big it will be difficult to turn off because of political pressures."

Rhode Island's plight and the problems other states are facing underscore the difficulty of what the systemic reform initiatives are attempting. Educator Thomas Sachse, who until last month directed California's program and is now with the California Science Project, a statewide teacher development program, remarks: "As one of my colleagues in Florida said, systemic reform is finding out everything that needs to be done and doing it first.

"It's like being a hummingbird: There's a lot of cross-pollination and flitting around. These are extremely ambitious programs. We are trying to connect every part of the system and monitor how things are changing. You need a team mechanism to create a very broad net."

The California SSI program is concentrating its resources on elementary science and middle-school mathematics, with the goal of preparing all students to take college-preparatory-level courses when they reach high school. The state is introducing up-to-date curricula and materials and working with colleges and universities to provide after-school and Saturday training for teachers. About 40% of California's 1,000 middle schools and about 25% of its 4,700 elementary schools are now participating, according to Sachse.

Systemic reform is fastest growing education division



a Current plan. b Budget request. **Source:** National Science Foundation

But the obstacles are large. For example, the philosophy underlying systemic education reform includes changing not just what children are taught and how but also how they are evaluated. Tests ideally should measure problem-solving skills and the ability to analyze—not just factual knowledge.

But California's Gov. Pete Wilson recently vetoed the state's controversial new assessment program, which Sachse considers very important to gauging how students are learning under the science education reform initiative. The testing program was sunk by the objections of some parents and conservative groups to what they saw as unsuitable meddling in children's feelings and belief systems—issues not specifically related to science education.

Sachse believes the SSI funds have allowed California to coordinate and assess its science education programs in ways it could not have done without NSF's involvement. But the NSF monies amount to only $2 million a year compared with the state's education budget of $30 billion—an example of what systemic reform's critics see as a major flaw.

"I don't want to be too critical; I'm taking a wait-and-see attitude, but it's unclear how dumping a few million dollars into a state can make that much difference," says Glenn A. Crosby, professor of chemistry and materials science at Washington State University, Pullman, and former chairman of the ACS Society Committee on Education.

Crosby voices the fears of many other onlookers who are more reluctant to speak for the record. NSF's funds, they worry, will be quickly institutionalized, frittered away on cities' and states' large bureaucracies, or spread so thinly they will have little effect.

Aldridge: criminal to limit staff

But EHR officials say the SSI and USI funds are not meant to pay the full bill but rather to push the cities and states in a new direction. "While NSF's several million dollars a year is not inconsequential," Williams says, "NSF is not really funding the total reform of the system. Our monies are designed to catalyze the redirection of the existing monies in the schools."

Danek cites as an example the recent decision by Ramon Cortines, chancellor of New York City public schools, to require that all high-school students take three years of advanced science and math courses. "NSF didn't pay for anything," he points out. "That's a policy change they are making because they accept the fact that under USI they are going to have to deliver students who are competent in science and mathematics at the end of their 12 years of education.

"Is NSF going to pay for the increased cost?" Danek muses. "No way! Cortines is going to have to figure out his own budget."

Although most of the education budgets of big cities are tied up in salaries and benefits, there is flexibility to redirect a significant amount. Both cities and states receive millions of dollars in Department of Education funds, for example, which Williams believes could be put to better use.

"What is it that would justify any of the nine cities to which we have made USI awards employing their resources in the mode they have for the past 20 years?" he asks. "There is nothing to recommend it. Why not try another option for, say, three years?"

In working with the USI cities, EHR has drawn on its experience with the states. EHR staff has tried to spell out exactly what is expected from USI participants and is working even more closely with the cities than it has with the states taking part in SSI. Williams has personally traveled extensively to spread the gospel among mayors, school officials, and local business leaders.

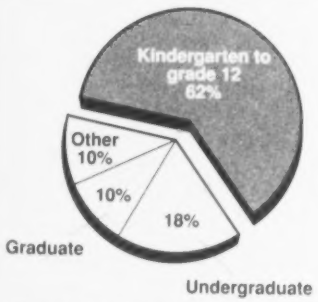
But the directorate's goal of constant interaction, monitoring, and feedback is hampered by lack of staff and funds for travel. To get around the shortages, most EHR program officers work extremely long hours. Because EHR staff members can't visit awardees as often as they believe is necessary, the city and state officials travel to NSF in Arlington, Va., on "reverse site visits."

"I think it's criminal to give an agency like that $600 million for science education and then limit their staff and refuse to provide the necessary travel budget so they can monitor these things," says Bill G. Aldridge, executive director of the National Science Teachers Association. "You can't just sit at a desk and hand out $600 million. If the government later finds out the money is wasted, it will be its own fault."

Williams is keenly aware of his directorate's responsibilities to the taxpayer. "Our Congressional appropriation is an authorization to spend a certain amount of money," he says. "At the end of the fiscal year, you've spent so many dollars and maybe, maybe, something has been accomplished. I am tasked to ask the question if in fact the quality of American science and mathematics education is substantially improved or changed by our efforts."

Indeed, the future of the systemic reform effort depends on demonstrating whether NSF money can make a lasting difference. The answer to that question should become apparent within a few years, after the educational system, Congress, and NSF itself have evaluated the systemic reform movement that has become a larger and larger part of the agency's education directorate. □

NSF education programs emphasize precollege level



Fiscal 1994 total = $570 million

Source: National Science Foundation